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FINAL REPORT OF OFF-SITE SURVEILLANCE FOR THE NRX-A6 REACTOR TEST SERIES

by
Environmental Surveillance
Western Environmental Research Laboratory

ENVIRONMENTAL PROTECTION AGENCY

Published August 1971

This surveillance performed under a Memorandum of Understanding (No. SF 54 373) for the Nevada Operations Office U. S. ATOMIC ENERGY COMMISSION

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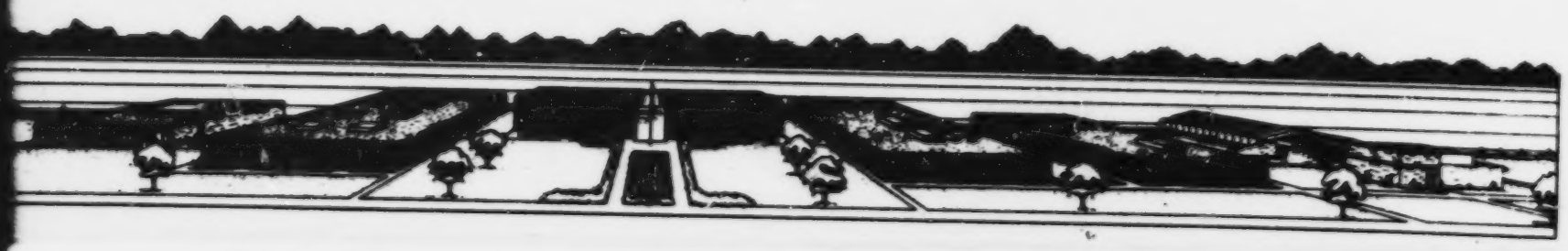

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*Formerly part of U. S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, Environmental Control Administration, Bureau of Radiological Health

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ABSTRACT

The NRX-A6 nuclear rocket test series consisted of three power tests from November 21 to December 15, 1967 at the Nuclear Rocket Development Station (NRDS), Jackass Flats, Nevada. Radioactive effluent was released to the off-site area from only the full power test, Experimental Plan IIIA (EP IIIA), on December 15.

Radioactive material was transported by prevailing winds along an azimuth of approximately 235°. Aerial and ground monitoring following the run detected levels of radioactivity above background in a sector from about 170° to 260° from Test Cell C, NRDS, to a distance of 200 miles.

Residents within 25 miles of Test Cell C, between azimuths of 210° and 250°, were advised to remain undercover from the beginning of the run to one hour after the run. Cooperation with this request was confirmed by EPA monitors assigned to these locations.

The maximum gamma exposure rate observed by a ground monitor using a portable GM survey instrument was 1.5 mR/h above background at Corder's Ranch in the Amargosa Farm Area near Lathrop Wells, Nevada, at 1253 hours PST. The maximum estimated infinite exposure, at the locations monitored, was 2.0 mR, 8.1 miles west of Lathrop Wells on Highway 95.

The maximum concentration of ^{131}I in air was 4.1 pCi/m^3 (0.4 $\mu Ci \cdot sec/m^3$ integrated exposure) at Death Valley Junction, California. This is the combined value of ^{131}I from both the particulate filter and charcoal cartridge. This amounts to less than 1 mrad inhalation dose to a hypothetical two-gram thyroid.

Iodine-131 was detected in milk from six sampling stations. The maximum concentration found was 90 pCi/l at Dansby's and Rooker's Ranches near Lathrop Wells. The maximum estimated radioiodine dose to a hypothetical two-gram thyroid was 8 mrad.

Particles, eroded from the reactor core, were found deposited on the ground out to 40 miles from the reactor. The maximum deposition density was 0.2 particles/m^2.

PREFACE

In accordance with Memorandum of Understanding, SF 54 373, the Western Environmental Research Laboratory (WERL) provides an off-site radiological safety program for the Atomic Energy Commission in support of nuclear tests conducted at the Nevada Test Site (NTS) and at the Nuclear Rocket Development Station, which lies within NTS. In this capacity, WERL is responsible for the following:

1. Documenting the radiological situation in off-site areas through comprehensive environmental sampling and radiation monitoring.

2. Assuring continuous protection of public health and safety by determining potential and past exposures to radioactivity, and implementing protective measures as directed by the Test Manager, AEC.

3. Conducting a public contact and information program in the off-site area to assure local residents that all reasonable safeguards are being employed to protect public health and property from radiation hazards.

4. Collecting information regarding incidents which may be attributed to radioactive releases to the off-site area.

Off-site areas are those outside the boundaries of NTS, the Tonopah Test Range, and the Nellis Air Force Range, which together are identified in this report as the Test Range Complex.

The WERL also represents the Environmental Protection Agency (EPA), and thereby maintains close working relationships with

surrounding states and other components of EPA. When any off-site radiological safety operation is conducted, all appropriate parties are kept advised and all state and EPA surveillance networks are alerted, as appropriate, to assist in documenting levels of radioactivity.

Note: At the time this work was performed, the Laboratory was named the Southwestern Radiological Health Laboratory and was a component of the Bureau of Radiological Health, Public Health Service.

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INTRODUCTION

On December 15, 1967, the full power test (Experimental Plan IIIA) of the NRX-A6 nuclear reactor was conducted at Test Cell C, Nuclear Rocket Development Station, beginning at 1059 hours, PST. For the purpose of measuring and documenting the effect that this test would have on levels of radiation and radioactivity in the environment outside the Test Range Complex, the Western Environmental Research Laboratory (WERL), Environmental Protection Agency, performed off-site radiological monitoring. This report summarizes the operational surveillance procedures used and presents the data obtained, with the exception of results from the special study on reactor-released particulates of high specific radioactivity and aerial monitoring using USAF and EPA aircraft. These latter results are reported separately [1, 2].

The NRX-A6 reactor was the sixth NRX engine tested by the NERVA Program (Nuclear Engine for Rocket Vehicle Application) of Project Rover, administered by SNSO (Space Nuclear Systems Office). The engine was tested through three experimental plans (EP's) on the dates and at the integrated power levels shown in Table 1 [3, 4, 5]. Airborne radioactivity was released during EP IIIA only.

Table 1. NRX-A6 Test Series - 1967.

EP	Date	Integrated Power (Mw· sec)
I	November 21	< 7
II	December 6	21
III	December 6, 7, 8	(Test Postponed)
IIIA	December 15	4.4×10^6

The purpose of EP IIIA was to evaluate engine performance at full power for 60 minutes. Radioactive gases and particulates were released by the combination of high core temperatures, high hydrogen coolant flow rates, and fuel element erosion and corrosion. The engine was positioned so that the effluent was directed upward.

PROCEDURES

Public Protection

Prior to the full-power test, the reactor effluent trajectory was predicted by NOAA (National Oceanic & Atmospheric Administration) to go to the southwest from Test Cell C. Since contact with radioactive particles within the effluent was considered probable for residents close to the test-site boundaries, preparations were made to keep undercover all residents of the Amargosa Farm Area within the predicted cloud path. Three EPA monitors were stationed in Lathrop Wells (population of 28 adults, 11 children) and 31 monitors were assigned to the 31 residences within the area bounded by Highway 95, a 25-mile arc from Test Cell C, and a line through Test Cell C and Lathrop Wells. All personnel were in two-way radio contact with the control point, prepared to advise residents to stay indoors.

Aerial and Ground Monitoring

Before the reactor test, mobile monitors were positioned within the downwind trajectory at populated locations and on existing roads and highways crossing the predicted cloud path to monitor radiation levels and collect environmental samples. About half of the 31 monitors were equipped with radiation survey instruments, gamma-rate recorders, thermoluminescent dosimeters, portable air samplers, and supplies for collecting environmental samples. The other personnel were equipped with radiation survey instruments only.

Following the release of radioactivity from the test, pertinent characteristics of the effluent were determined by aerial monitoring. The cloud tracking team in a USAF U-3A aircraft defined the boundaries and hotline of the radioactive effluent. A EPA Turbo-Beech aircraft was used to perform cloud sampling, cloud tracking, and other documentation. All tracking information from the aircraft was radioed immediately to a control center where it was used in conjunction with meteorological and on-site monitoring information to assist in placing ground monitors in the downwind area, as required.

Following cloud passage, the effect of the test on the environment was determined from comprehensive monitoring and sampling. Monitors obtained radiation readings and collected vegetation, milk, cow feed, and water samples in off-site areas out to 141 miles from Test Cell C. Additional milk samples were collected from Grade A dairies as far as 272 miles from Test Cell C.

Survey Instruments

The aircraft and ground monitors were equipped with Geiger-Mueller (GM), gamma scintillation, and ionization chamber survey instruments. The GM instrument has a range of 0-200 mR/h on four linear scales using an external GM tube with a sliding shield. A range of 0-2000 mR/h is provided by an internal GM tube. The gamma scintillation instrument has a range of 0-3 mR/h on four linear scales. The ionization chamber survey instrument has a range of 0.05 to 50,000 mR/h on two logarithmic scales. These instruments are calibrated with a ^{137}Cs source and are accurate to $\pm$ 20%. Exposure rate readings can be read to two significant figures.

Gamma-Rate Recorders

A network of 28 continuously operated gamma-rate recorders (Eberline RM-11) was located around the Test Range Complex at the locations shown in Figure 1. These instruments measure radiation exposure rates over a range of 0.01 to 100 mR/h with a GM detector and record the levels on a 30-hour strip chart. The instrument is accurate to $\pm$ 20%, as calibrated with a ^{137}Cs source.

Portable gamma-rate recorders carried by monitors use the same 0-2000 mR/h GM survey instrument mentioned in the section on Survey Instruments, coupled to a battery-powered strip-chart recorder. These recorders were used to supplement the routine network of gamma-rate recorders and the radiation readings taken by monitors. The enclosure for each recorder also contained two thermolumines-cent dosimeters described in the following section.

Dosimeters

A routine dosimetry network of film badges and thermoluminescent dosimeters (TLD's) is operated continuously. This network is shown in Figure 2. At the time of NRX-A6, there were approximately 90 stations, each equipped with five film badges. Eighty-six of these stations also were each equipped with three TLD's. In addition, 137 off-site residents were badged with one film packet each and all monitors were issued one TLD for a personnel dosimeter. Two TLD's were were placed in each portable gamma-rate recorder.

The dosimetry film used by the EPA network is a Dupont Type 545 single emulsion film packet with a useful range of about 30 mR to 3 R. Reading accuracy is $\pm$ 50% from 30 to 100 mR and $\pm$ 10% from 100 to 2000 mR for gamma radiation above 50 keV.

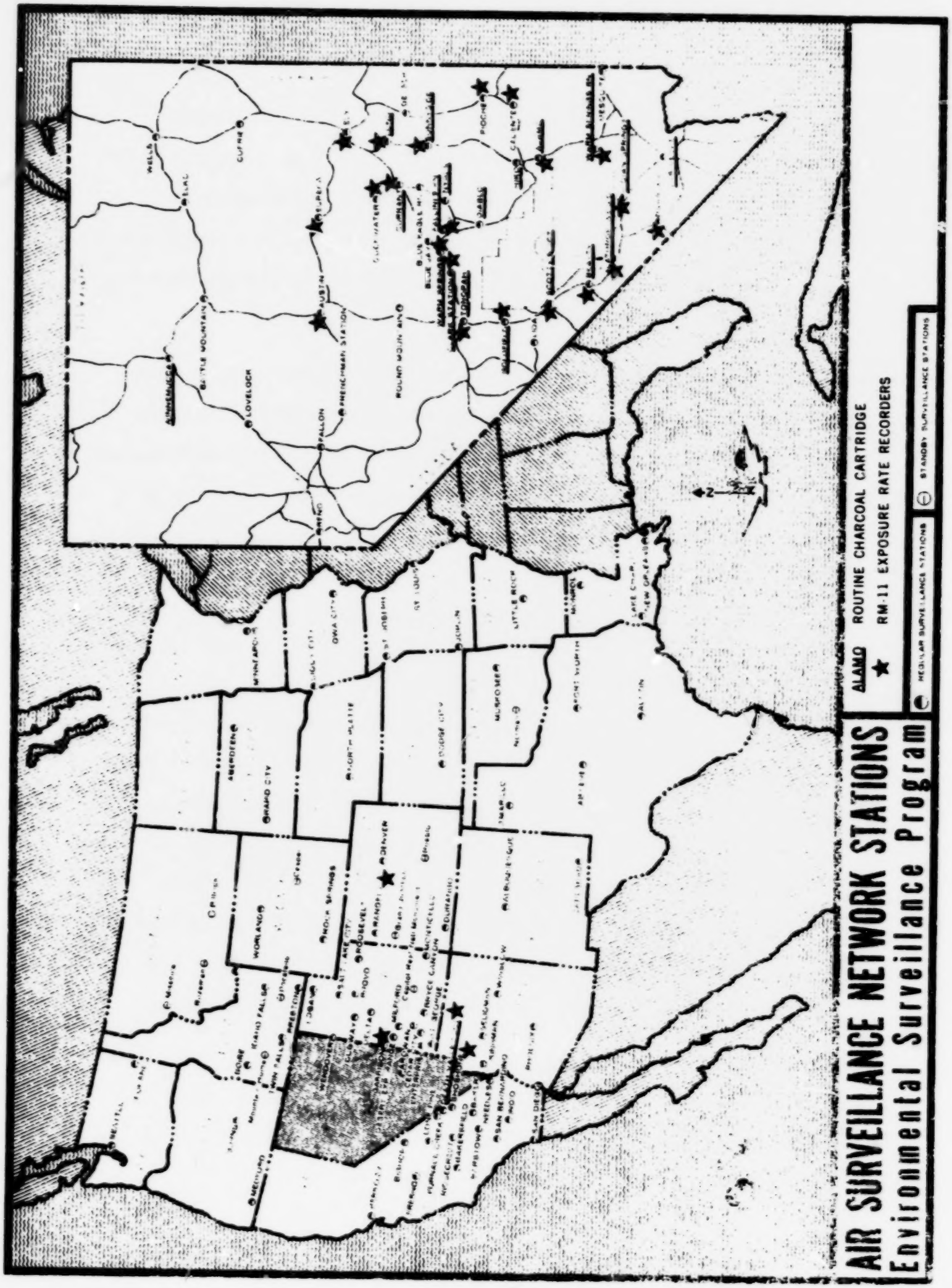


Figure 1. ASN air sampling stations and RM-11 locations, NRX-A6, EP IIIA.

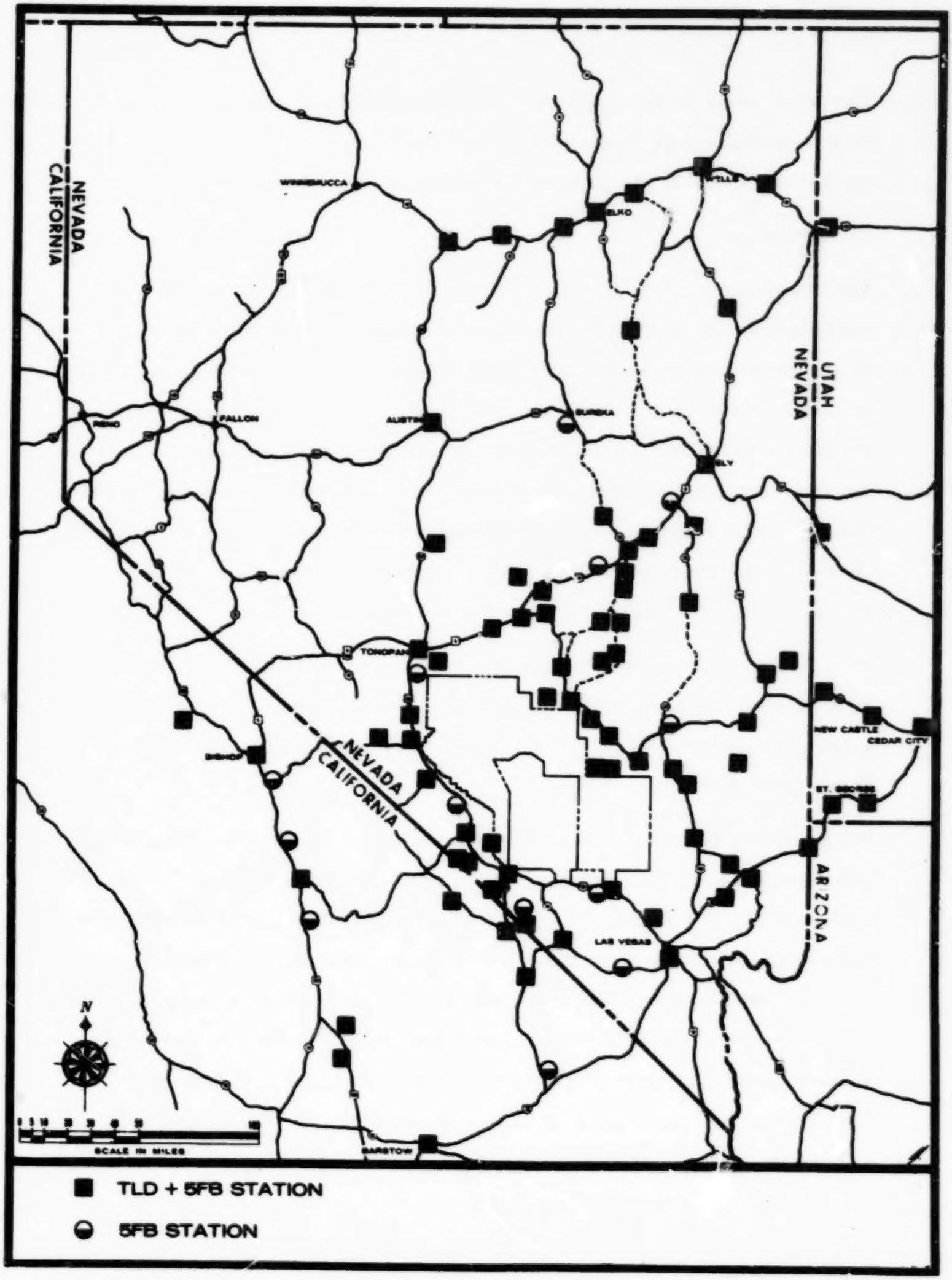


Figure 2. Routine dosimetry stations, NRX-A6, EP IIIA.

The TLD used in the network is the EG&G Model TL-12 dosimeter with a useful range from about 1 mR to 5000 R. The overall reading accuracy is ± 10% for gamma radiation above 50 keV.

Air Samples

The routine network of about 100 permanent air samplers of the Air Surveillance Network (Figure 1) is used for measuring concentrations of airborne radioactivity on a daily basis. These stations, sampling at about 10 cfm, collect airborne particulates on 4-inch-diameter Whatman 541 filters. Twenty of the stations immediately surrounding the Test Range Complex operate routinely with a 4-inch-diameter charcoal cartridge behind a particulate filter. By telephone request, charcoal cartridges are placed in additional stations and the standby stations are activated.

Portable air samplers carried by field monitors supplemented the ASN stations to cover cloud passage. These samplers also used 4-inch-diameter filters and charcoal cartridges and operated at about 12 cfm.

All particulate filters were counted for gross beta radioactivity on a low-background, thin-window, proportional counter. Results were reported in pCi/m^3 and $\mu Ci \cdot sec/m^3$ extrapolated to end of collection time. Those particulate filters that contained reactor-related radioactivity and all charcoal cartridges were analyzed by gamma spectrometry with a 4- by 4-inch NaI crystal and multi-channel analyzer. The concentrations of individual radionuclides were reported in pCi/m^3 and $\mu Ci \cdot sec/m^3$ extrapolated to end of collection. For gross beta and radioiodine radioactivity the minimum detectable activity (MDA) was 0.1 pCi/m^3 for a ten-minute count.

Vegetation Samples

Following cloud passage, samples of natural vegetation were collected along highways and at populated locations to augment or substantiate other evidence of the radioactive deposition pattern. Samples were counted for gross gamma radioactivity and qualitatively analyzed by gamma spectrometry to determine whether samples were positive or negative for test-related radioactivity.

Samples of cow feed were collected at the milk sampling locations listed in Appendix D and analyzed by gamma spectrometry. The concentrations of individual radionuclides identified in the samples were reported in pCi/kg if greater than the MDA of 50 pCi/kg for a ten-minute count.

Milk Samples

One-gallon milk samples were collected from family milk cows located within the cloud path. Samples of 3.5 liters were analyzed by gamma spectrometry techniques. The lower limit of detection for ^{131}I and ^{133}I is about 10 pCi/l for a 20-minute counting time. Samples containing test-related radioactivity were also analyzed by radiochemistry techniques for ^{89}Sr and ^{90}Sr, which have MDA's of 5 pCi/l and 2 pCi/l, respectively.

Water Samples

One-gallon water samples were collected within the effluent trajectory from stock tanks at locations where milk samples were collected and from potable water sources. All samples were analyzed by gamma spectrometry. Those samples containing test-related radioactivity were also analyzed by radiochemistry methods for ^{89}Sr and ^{90}Sr. The minimum detectable concentrations were the same as those for milk.

Particle Study

A search was made to locate, collect, and analyze particles of high radioactivity which were deposited on the ground downwind of the Test Cell. The deposition density (number of particles per square meter) was determined and selected particles were analyzed for isotopic and gross beta radioactivity, size, density and chemical composition.

RESULTS

Public Protection

Shortly after the full-power test was started, residents found within the area shown in Figure 3 were advised to stay indoors until one hour after the end of the test. All the people cooperated and no complaints were received. Results of post-test deposition surveys (2, pp. 6-10) confirm that the residents contacted were within the affected area.

Monitor Readings

Figure 4 shows the locations of monitors during cloud passage, lists their maximum gamma exposure-rate readings obtained with GM survey instruments, and lists the integrated radiation exposure at each location. These exposures were estimated by integrating the cloud passage radiation readings with time, assuming that any radioactive ground deposition decayed in accordance with $t^{-1.2}$.

The hotline of 235° shown in Figure 4 was based upon the integrated exposures estimated from the monitor readings. This hotline agrees well with results from vegetation sampling and from aerial monitoring (2); however, it differs with the particle hotline of 219° found by the particle study (1). This may be explained by the variation of wind direction with altitude during cloud passage.

According to a post-test evaluation (6) of meteorological conditions during and following EP IIIA, the trajectories of effluent released at the beginning of the test at 10,000, 8,000 and 4,600 feet mean sea level (MSL) were southwest of Test Cell C along azimuths of about 255°, 237°, and 218°, respectively, with some curvature to the

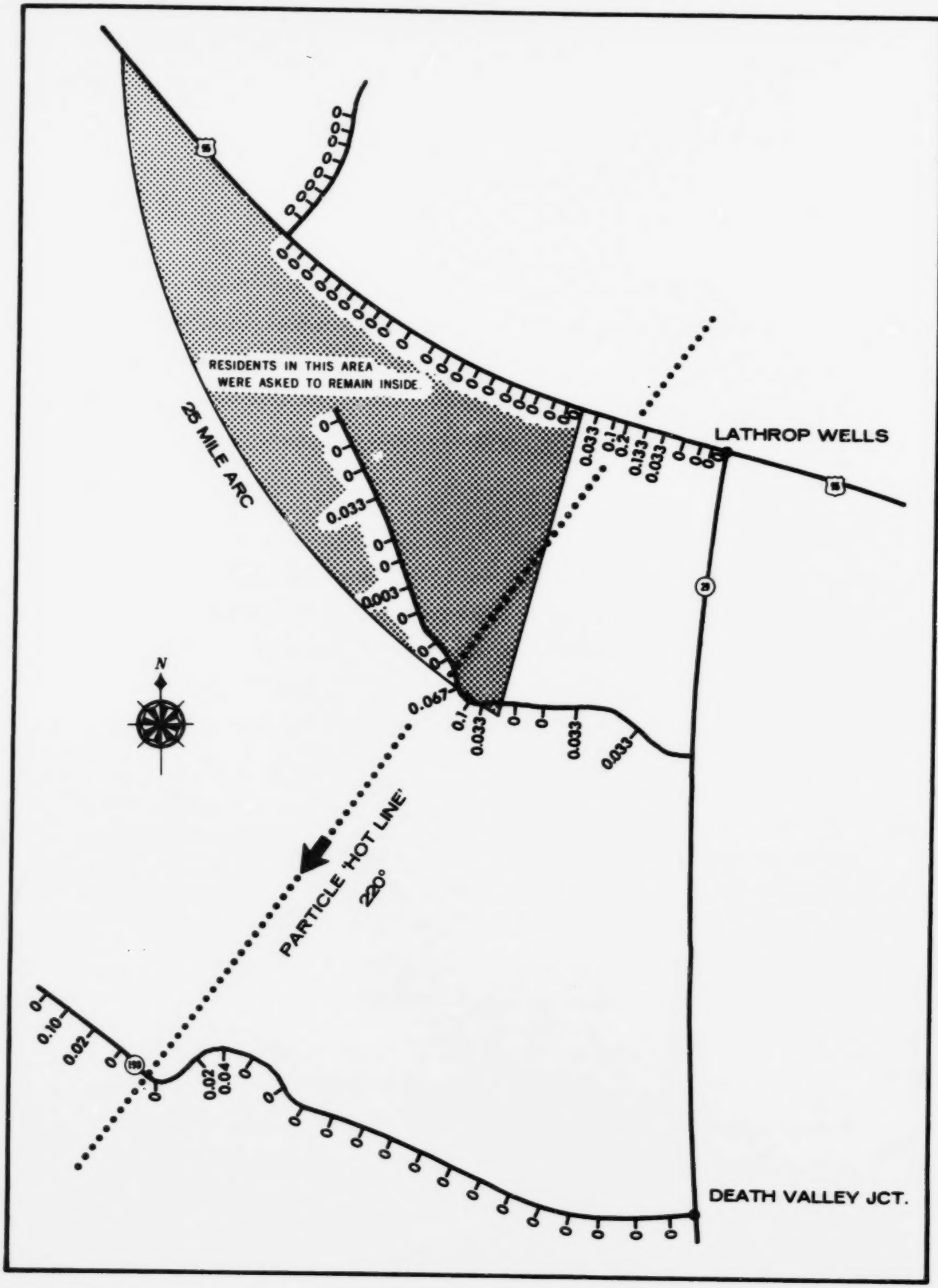
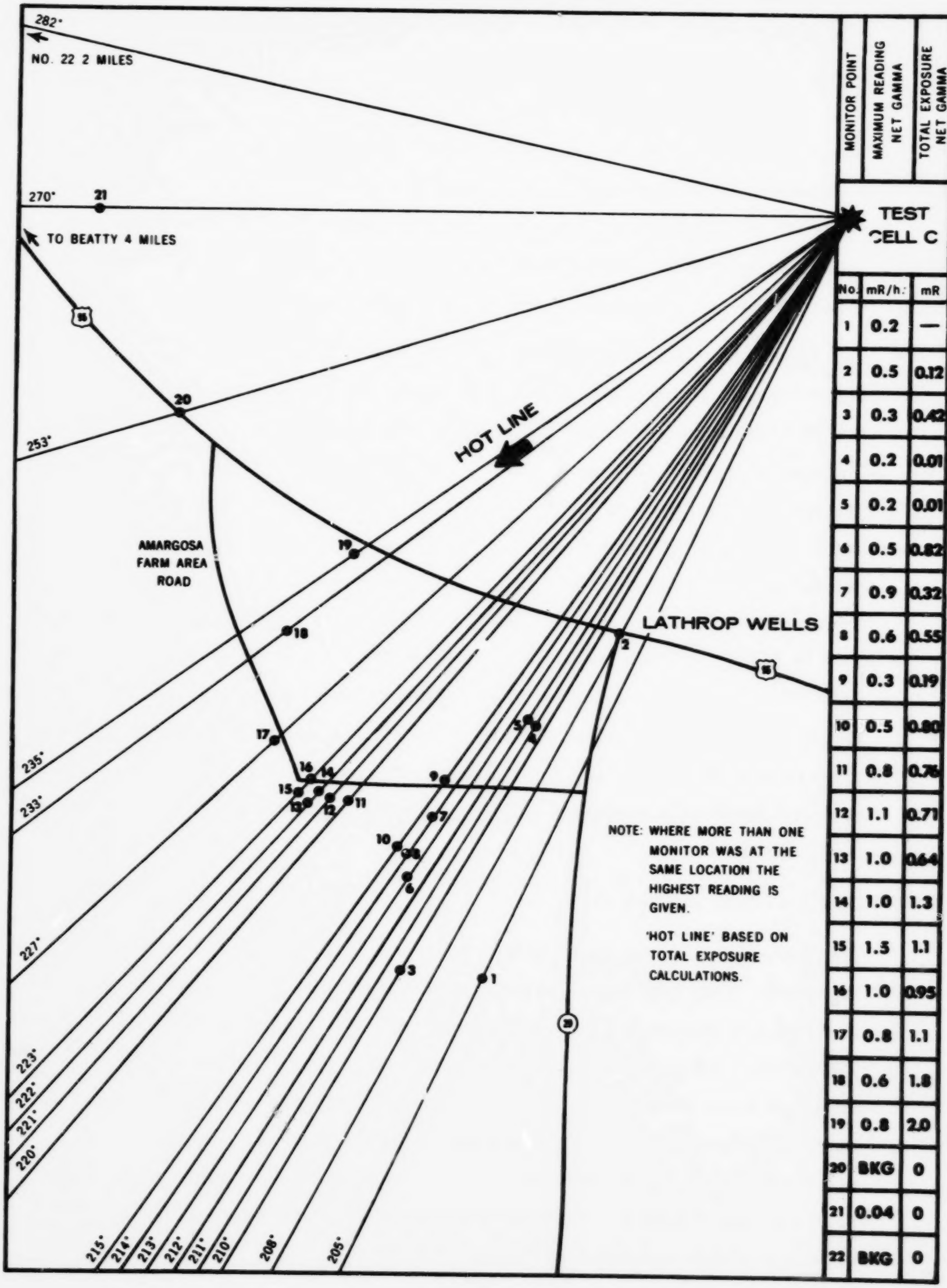


Figure 3. Location of notified residents and results of particle surveys, NRX-A6, EP IIIA.



MONITOR POINT	MAXIMUM READING NET GAMMA	TOTAL EXPOSURE NET GAMMA
No.	mR/h.	mR
1	0.2	—
2	0.5	0.12
3	0.3	0.42
4	0.2	0.01
5	0.2	0.01
6	0.5	0.82
7	0.9	0.32
8	0.6	0.55
9	0.3	0.19
10	0.5	0.80
11	0.8	0.78
12	1.1	0.71
13	1.0	0.64
14	1.0	1.3
15	1.5	1.1
16	1.0	0.95
17	0.8	1.1
18	0.6	1.8
19	0.8	2.0
20	BKG	0
21	0.04	0
22	BKG	0

Figure 4. Ground monitoring results, NRX-A6, EP IIIA, 12/15/67.

south. From aerial monitoring results [2] the altitude of maximum radioactivity was found at 8,500 feet MSL. Since the large particulates in the reactor effluent would not be ejected as high as the gaseous portion of effluent at 8,500 feet, the trajectory of particles would be at an azimuth less than 237°, closer to Lathrop Wells.

In addition to those readings shown in Figure 4, other readings taken by mobile monitors from Lathrop Wells, Nevada to Shoshone, California, and from Death Valley Junction, California through Furnace Creek, California, showed a maximum of 0.6 mR/h above background 24 miles S.E. of Furnace Creek on Highway 190 (200°, 38 mi.). Readings slightly above background were found by monitors in the Owens Valley along Highway 395. The maximum recorded was 0.1 mR/h 5 miles S. of the Junction of Highways 395 and 14 (228°, 112 mi.). Remonitoring of the Amargosa Farm Area on 12/16 - 12/17 showed residual activity on two haystacks; one at Dansby's Ranch and one at Hoard's Ranch. Contact readings indicated a maximum of about twice instrument background at both ranches. A more detailed listing of ground monitoring results can be found in Appendix B.

Gamma-Rate Recorders

Ten battery-powered gamma-rate recorders were placed at 2.5-mile intervals along Highway 95 west of Lathrop Wells. The GM survey instruments connected to the recorders were set for 20 mR/h and 200 mR/h full scale based upon an expected exposure-rate along Highway 95 of 70 mR/h. Since the maximum exposure rate observed along Highway 95 was only 0.8 mR/h, cloud passage was not documented by the recorders. Thermoluminescent dosimeters (TLD's) placed with the exposure-rate recorders measured no exposure above normal background.

Two RM-11 gamma-rate recorders showed radiation above background levels on December 15. The RM-11 at Lathrop Wells showed a cloud arrival time of 1135 hours, a peak reading of 0.3 mR/h and an estimated integrated gamma exposure of less than 0.1 mR. No deposition was indicated by the RM-11 recorder. The RM-11 at Death Valley Junction showed a cloud arrival time of 1300 hours, a peak reading of 0.2 mR/h the presence of deposition which decayed proportional to $t^{-1.92}$, and an integrated gamma exposure of 0.5 mR.

Dosimeters

All ground monitors were issued film badges and TLD dosimeters. None of these devices nor any of the TLD's in the routine dosimetry network showed exposures above background.

Air Sampling

Fresh fission products from the reactor test and from reactor-pulse-cooldown operations (conducted until December 18) were detected on the filters of air samplers operated at the locations shown in Figures 5, 6, 7, and 8. These samples were collected at various times during the period December 15 through 19. All stations were part of the continuously operated Air Surveillance Network except for five portable samplers located in the Amargosa Valley southwest of Test Cell C, three portable samplers along Highway 95 between Lathrop Wells and Beatty, and five portable samplers along Highway 395 south of its junction with Highway 14 near Ridgecrest, California. The portable samplers operated only during cloud passage of the reactor effluent from the full-power test except for the one at Dansby's Ranch which was operated on December 16 and 17.

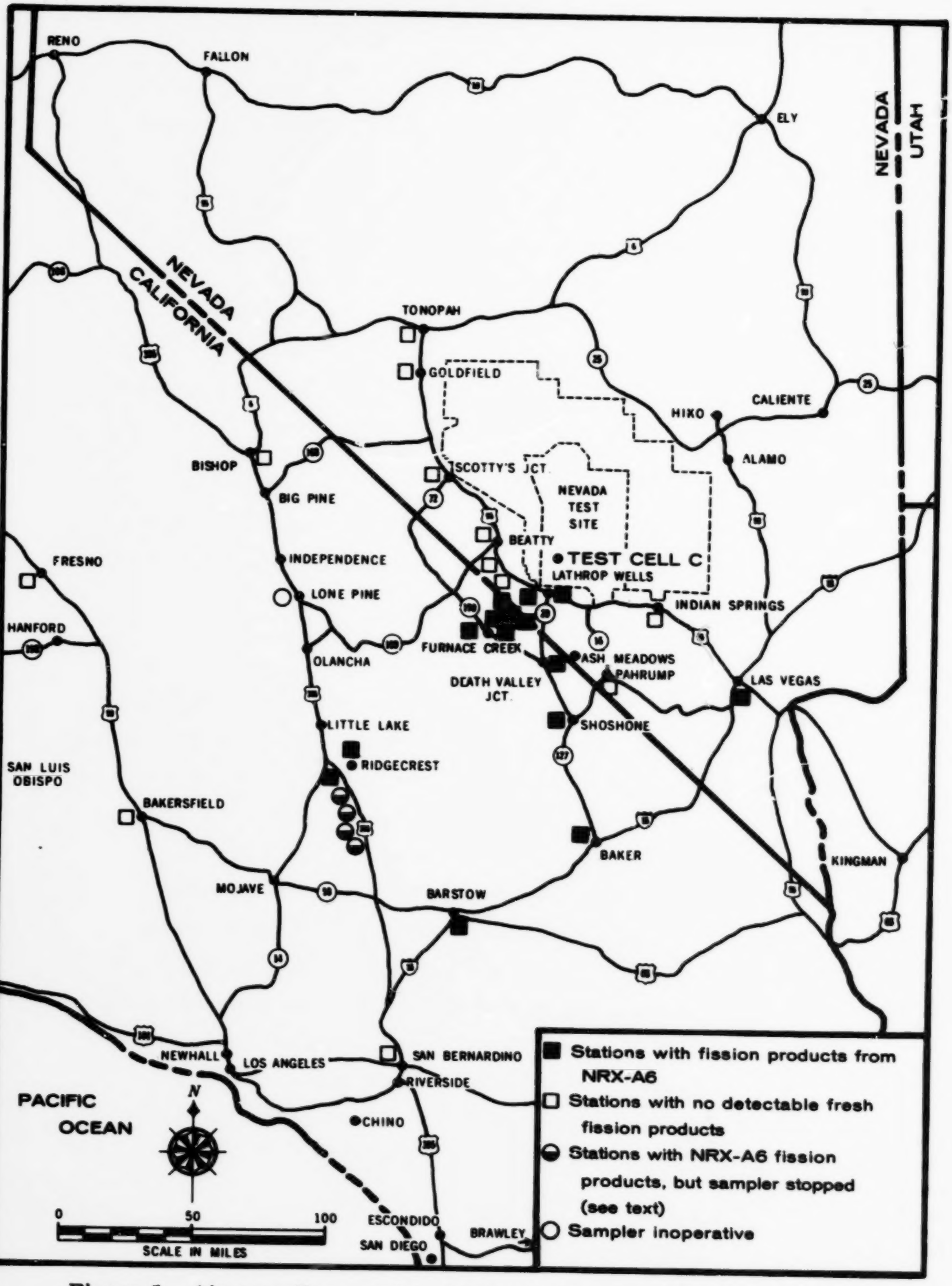


Figure 5. Air sampling results, NRX-A6, EP IIIA, 12/15/67-12/16/67.

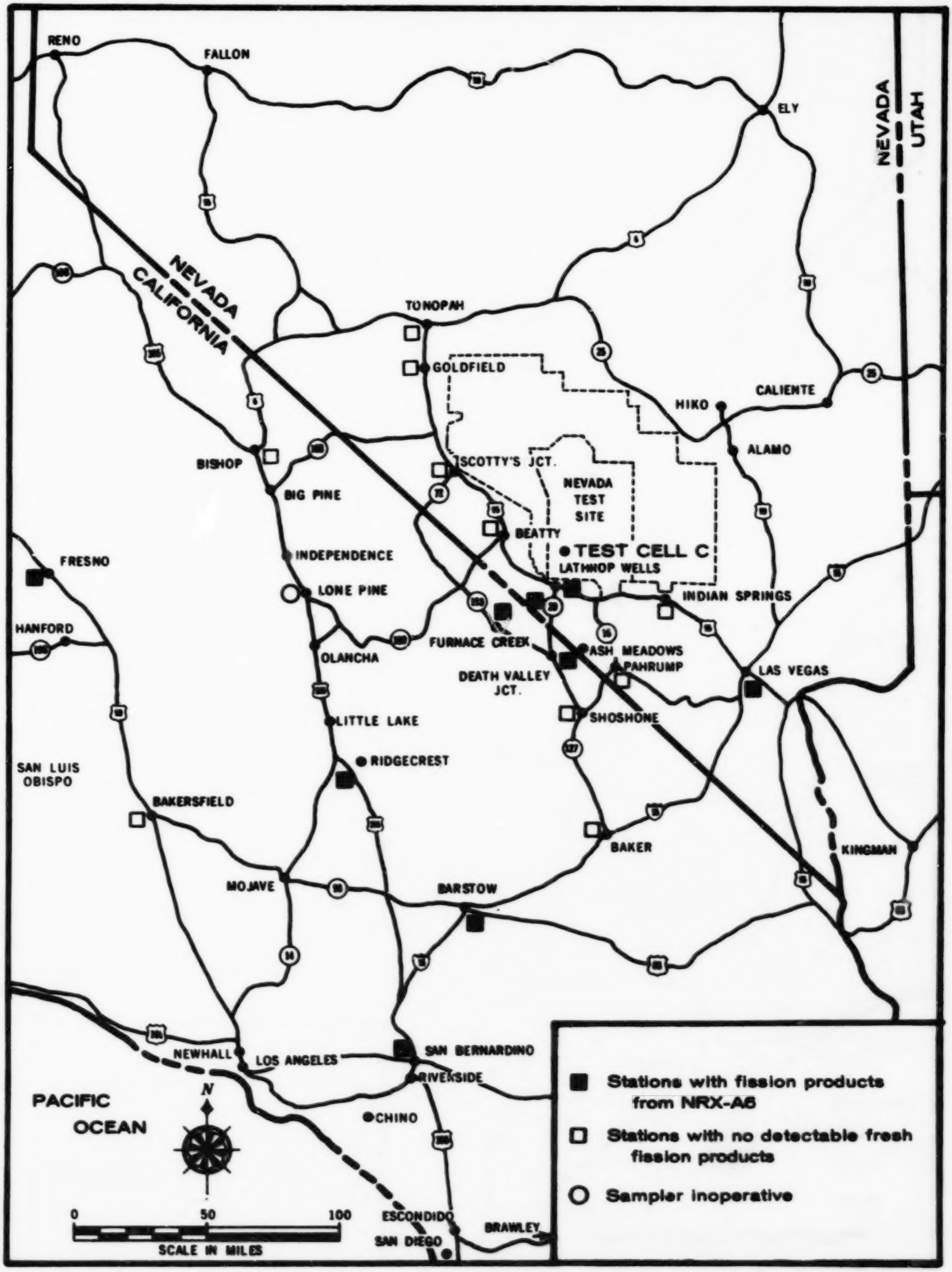


Figure 6. Air sampling results, NRX-A6, EP IIIA, 12/16-12/17/67.

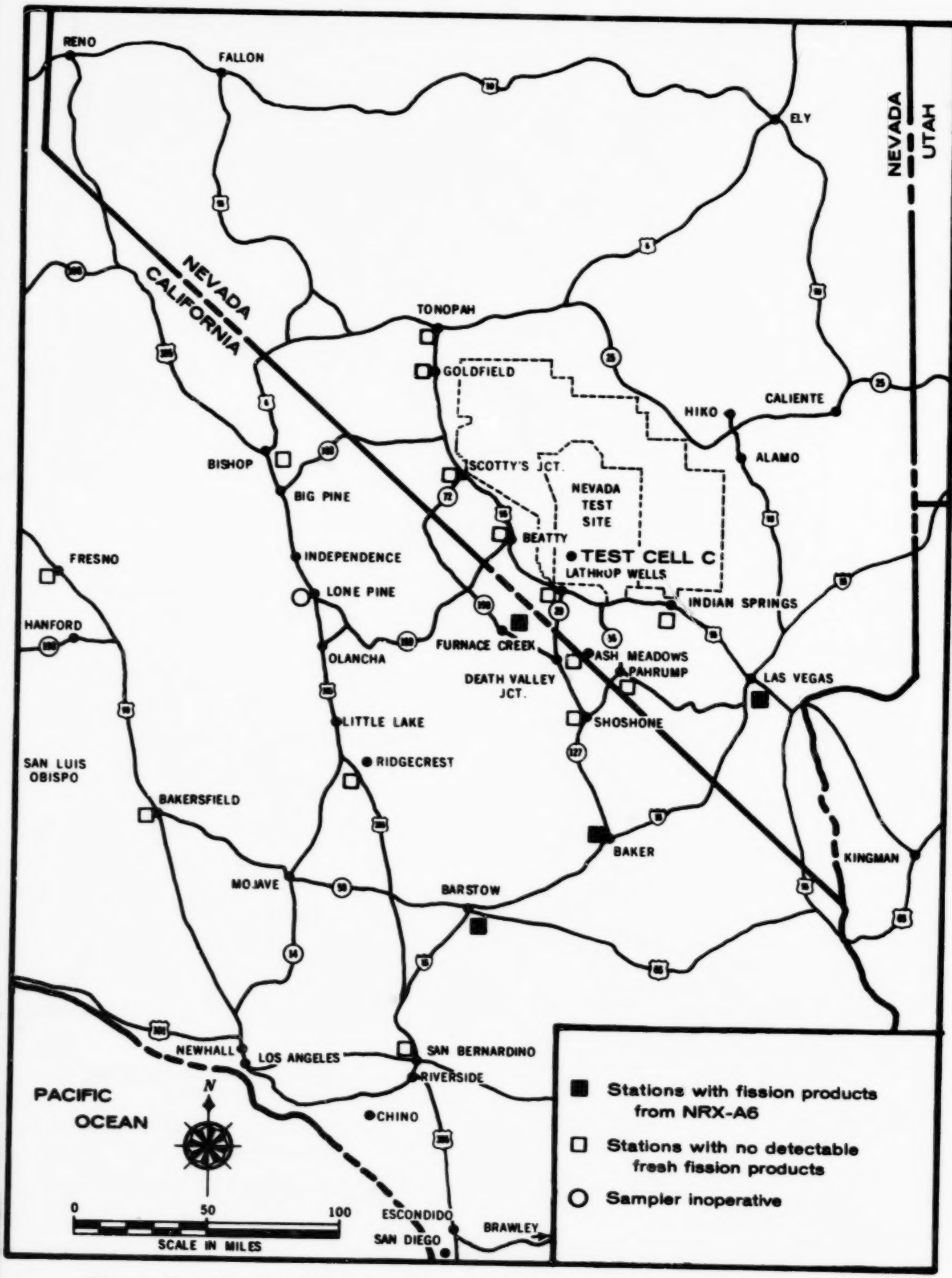


Figure 7. Air sampling results, NRX-A6, EP IIIA, 12/17-12/18/67.

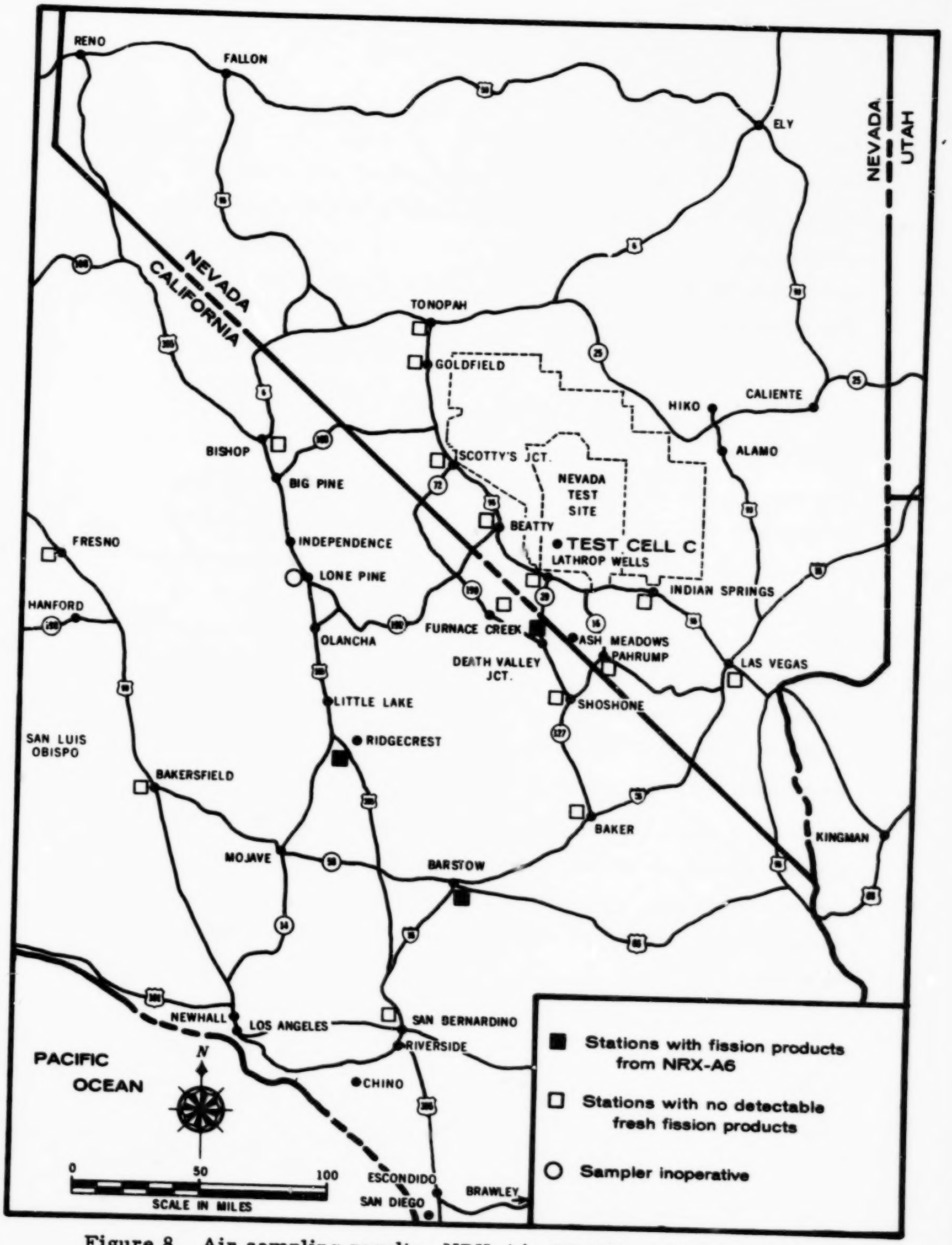


Figure 8. Air sampling results, NRX-A6, EP IIIA, 12/18-12/19/67.

Appendix C lists the concentrations of gross beta radioactivity and of all identified radioisotopes in units of pCi/m^3 and $\mu Ci \cdot sec/m^3$. From the time integrated concentrations ($\mu Ci \cdot sec/m^3$) at each air sampling location, the hypothetical radiation doses to an adult's and child's thyroid were estimated by the method described in Appendix A. The maximum inhalation dose was < 1 mrad to a hypothetical 2 gram thyroid at the Hord and Nickel Ranches in the Amargosa Farm Area.

Milk and Milk Cow Feed

One hundred and six milk samples were collected from 21 separate locations shown in Figure 9. Of these, 21 samples from six locations contained radioactivity from NRX-A6. The maximum concentration was 90 pCi/l of ^{131}I and 400 pCi/l of ^{133}I found in a sample from Dansby's Ranch near Lathrop Wells, Nevada. Table 2 shows the maximum concentrations of ^{131}I at each of the six locations where fresh fission products were detected. Included in this table are the estimated dose from radioiodines to a hypothetical child's thyroid based upon the assumptions in Appendix A.

Appendix D shows the complete milk sampling results at all stations where NRX-A6 activity was detected along with the results of milk cow feed samples. Appendix E shows the remainder of the milk sampling effort at stations where no fresh fission products were detected.

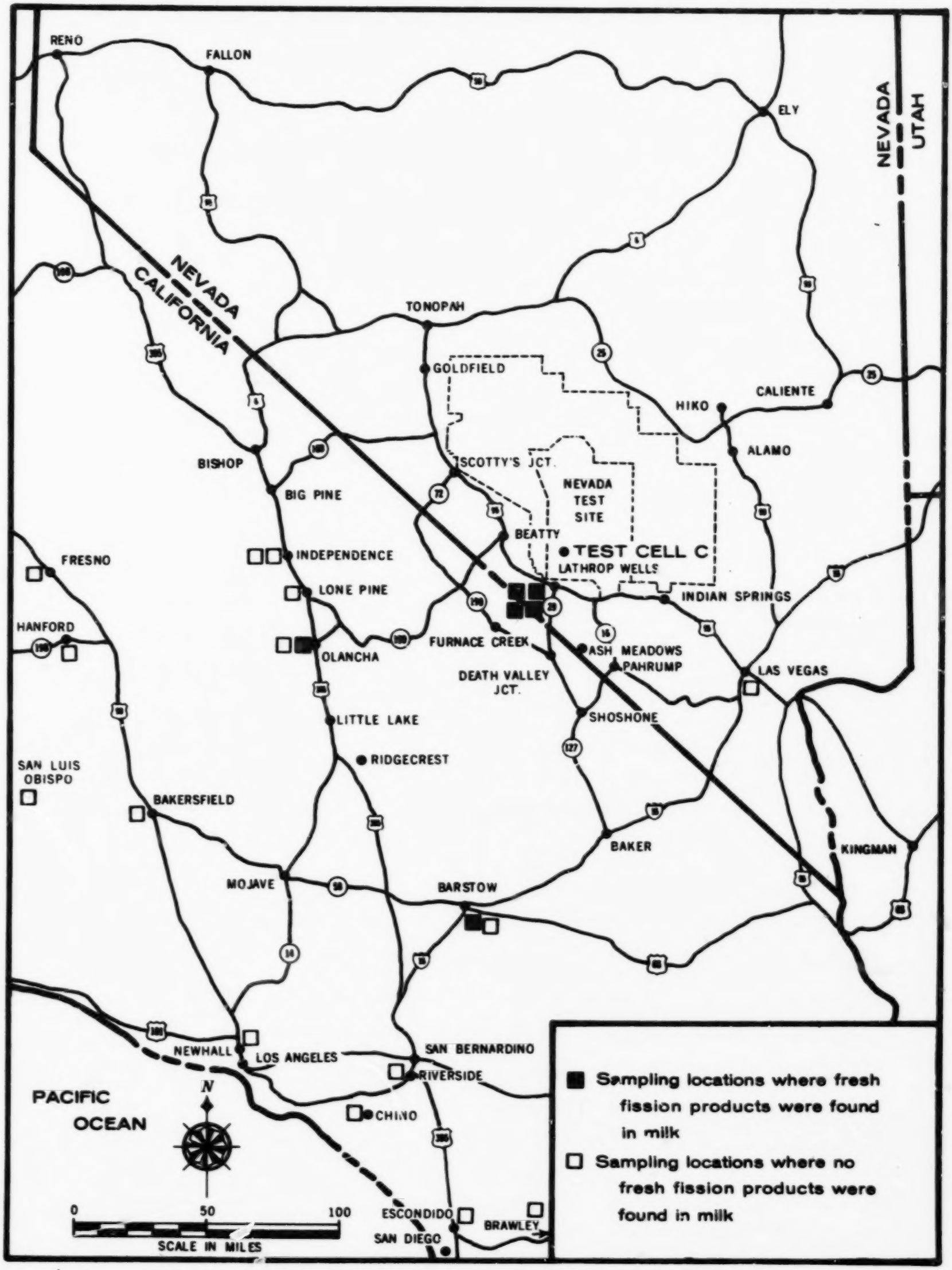


Figure 9. Milk sampling results, NRX-A6, EP IIIA.

Table 2. Estimated hypothetical thyroid dose from radioiodine in milk* from six stations showing the six highest concentrations of ^{131}I, NRX-A6 EP IIIA.

Name and Location of Dairy or Ranch	Date Milked	Peak Radionuclide Conc. (pCi/l)				Maximum Thyroid Dose (mrad)
		^{131}I	^{133}I	^{89}Sr	^{90}Sr	
Lathrop Wells, Nevada Dansby's Ranch	12/16	90	400	< 5	2	8
Lathrop Wells, Nevada Rooker Ranch	12/18	90	70	< 5	3	8
Lathrop Wells, Nevada Hord Ranch	12/18	80	50	< 5	< 2	3
Lathrop Wells, Nevada Tom Nickell Ranch	12/17	40	80	< 5	< 2	2
Barstow, California Bill Nelson Dairy	12/17	20	50	< 5	2	1
Olancha, California Hayhurst Ranch	12/18	20	ND	< 5	3	< 1

*These estimates are based upon a hypothetical ingestion of 1 liter of milk per day and a thyroid weight of 2 grams with an uptake of 30% of the available iodine in the milk.

Water Samples

Seventy-nine water samples from open and closed water supplies were collected in the Amargosa Farm Area, the area around Death Valley Junction, Furnace Creek, and the Owens Valley as far south as Barstow, California. Three samples from open sources contained NRX-A6 activity. The results of these three samples are shown in Table 3. Gross beta activity does not include the radioiodines as these are lost in sample preparation for gross beta counting. No samples of water used for human consumption showed detectable amounts of fresh fission products.

Table 3. Water samples with fresh fission products, NRX-A6 EP IIIA.

Location	Date	Source	Gross Beta (pCi/l)	Radionuclide Concentration (pCi/l) ^{131}I	^{132}Te	^{133}I	^{89}Sr	^{90}Sr
Lathrop Wells, Nevada Nickell Ranch	12/16	Stock Tank	100	ND	ND	200	< 5	< 2
Lathrop Wells, Nevada Rooker Ranch	12/16	Stock Tank	28	ND	ND	210	< 5	< 2
Barstow, California	12/16	Rain Pool	200	880	180	2500	No Chemistry	

ND - Not Detected

Natural Vegetation

Figure 10 shows all locations where samples of native vegetation were collected and whether or not the samples contained radioactivity attributable to the NRX-A6 operation. Figure 11 shows the results of close-in sampling (out to approximately 50 miles) in relative numbers. As can be seen from this figure, the movement of the released activity was to the southwest moving more southerly with the passage of time.

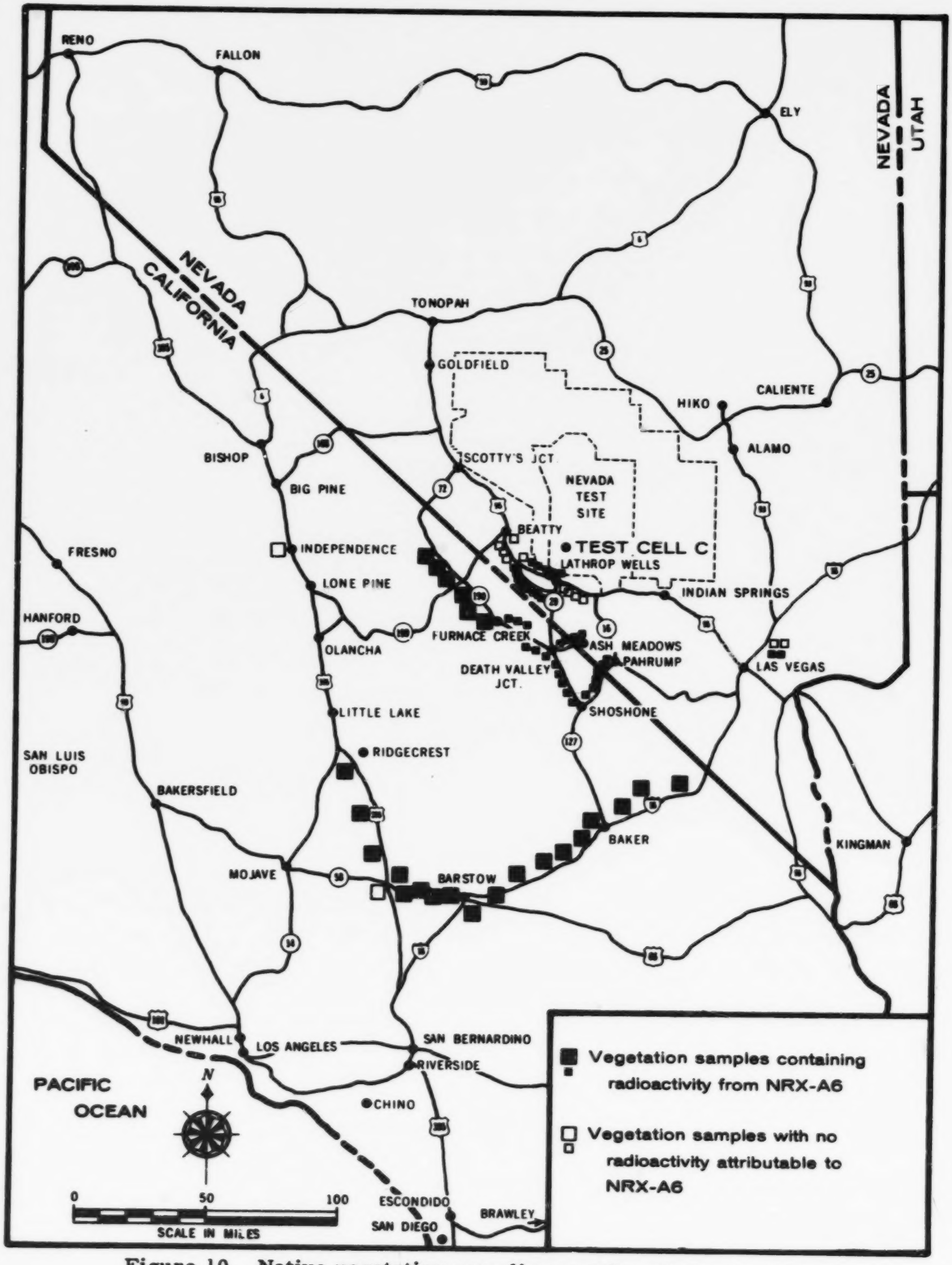


Figure 10. Native vegetation sampling results, NRX-A6, EP IIIA.

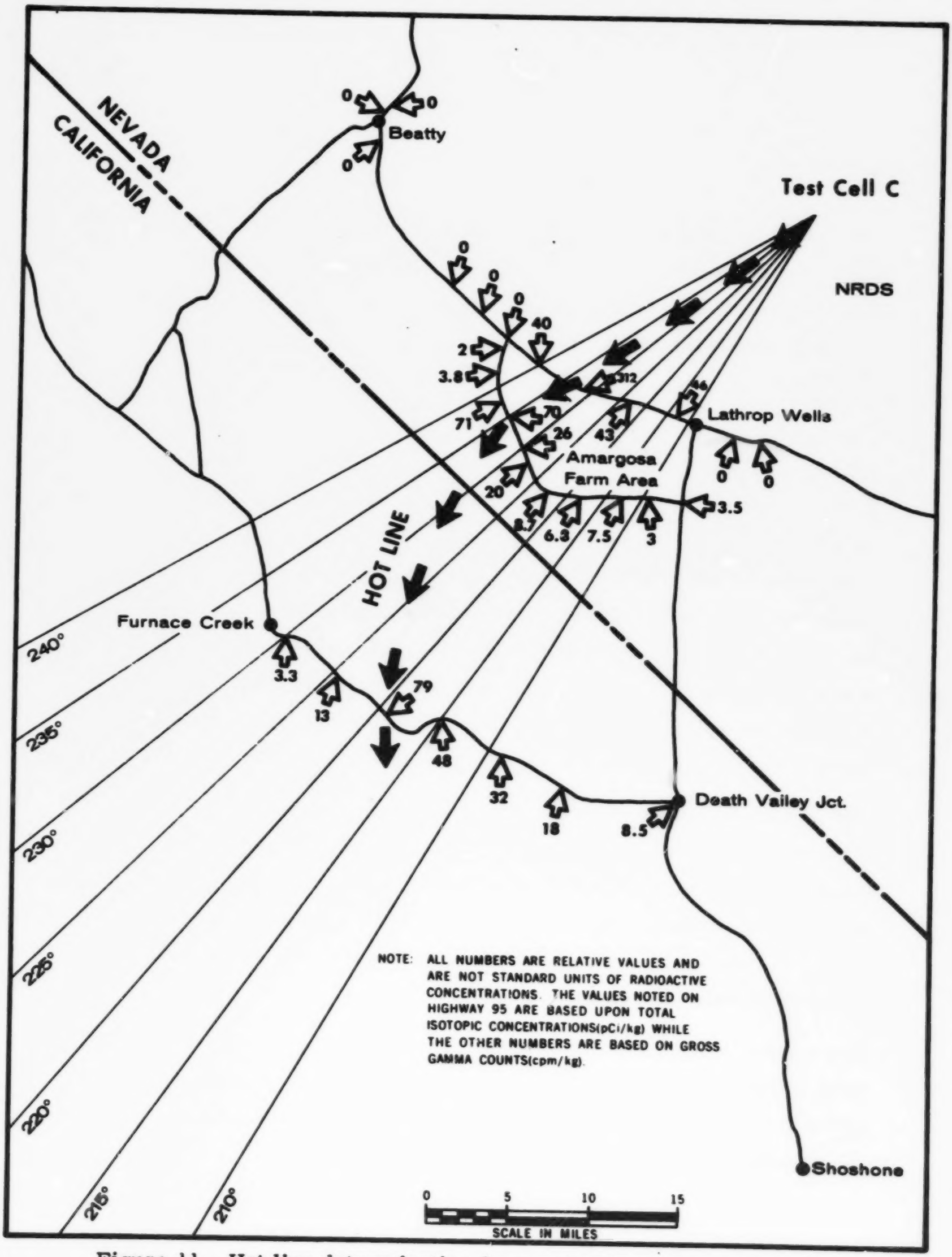


Figure 11. Hot line determination from natural vegetation sampling.

DISCUSSION AND SUMMARY

The NRX-A6 EP IIIA reactor released airborne radioactivity during its full-power operation and during pulse-cooling after the test. Unstable weather conditions caused the material to be spread over a rather large area from almost due west to due south from Test Cell C.

Just prior to reactor operation, 31 EPA monitors moved into the Amargosa Farm area for the purpose of asking people in the area to remain undercover. The area covered is shown in Figure 3. Monitors remained at, or near, the residences until they were instructed by Net Control to inform the people to resume normal activities. All the people cooperated well and no adverse comments were reported. The purpose of this protective action was to minimize possible exposure to particulates of high activity released from the reactor fuel elements. The physical properties of these particles are the subject of a separate report [1].

The maximum measured integrated whole body gamma exposure to a populated location was 1.8 mR at the McCarthy/Catlett Ranch. Since the residents were undercover during cloud passage, the actual exposure would have been less. This exposure was about one percent of the radiation protection standards for a suitable sample of the off-site population (i.e. 170 mrem/year).

The maximum inhalation exposure to a hypothetical 2-gram thyroid from airborne radioiodines was less than 1 mrad as measured by portable air samplers in the same general area as the maximum gamma exposure.

Milk from all known lactating milk cows in the Amargosa Farm Area was sampled. Analytical results from these samples are given in Appendix D.

The maximum postulated thyroid dose from inhalation and ingestion of radioiodines was about 8 mrad for a one-year-old child. This model represents a critical receptor with a 2-gram thyroid and one liter of milk consumption per 24 hour period and does not indicate a dose to any one individual. The maximum dose of radiation in milk from which these figures were postulated occurred at Dansby's Ranch.

This postulated exposure is approximately two percent of the presently accepted guides of 500 mrad thyroid dose per year.

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APPENDIX A

METHODS OF CALCULATING THYROID DOSE

The dose rate to the thyroid may be described by the equation

$dD/dt = K\ E\ A \exp -(\lambda_{eff} t)$ where:

dD/dt = dose rate per unit time

K = dimensional constant

E = effective energy of beta and gamma radiation, MeV per disintegration

A = concentration of radioiodine in thyroid, $\mu Ci/g$

λ_{eff} = effective decay constant, time $^{-1}$

t = time after deposition in thyroid

This assumes that the radioiodine is uniformly distributed throughout the thyroid and that the size of the thyroid is large compared to the range of the beta particles.

The total dose is estimated by integrating the above equation from time zero to infinity assuming D = O at time zero.

$$D = KEA \int_o^\infty \exp -(\lambda_{eff} t)\, dt$$

$$D = (-1/\lambda_{eff})\, KEA \exp -(\lambda_{eff} t) \Big|_o^\infty$$

$$D = O + KEA/\lambda_{eff}$$

Dose from Inhalation of Radioiodines

The actual values for the parameters in the dose equation for ^{131}I are as follows:

$$K = \frac{1 \text{ rad}}{100 \text{ erg/g}} \times \frac{\text{erg}}{6.24 \times 10^5 \text{ MeV}} \times \frac{3.7 \times 10^4 \text{ dis}}{\mu Ci \cdot sec} \times \frac{8.64 \times 10^4 \text{ sec}}{\text{day}}$$

$$K = \frac{51.2 \text{ rad} \cdot \text{gm} \cdot \text{dis}}{\text{MeV} \cdot \mu\text{Ci} \cdot \text{day}}$$

$$E = 0.23 \text{ MeV}$$

$A = \frac{\chi B f}{m}$, where:

χ = time-integrated concentration of radioactivity, $\mu\text{Ci} \cdot \text{sec}/\text{m}^3$

B = breathing rate of standard man, averaged over 24 hours, $2.32 \times 10^{-4} \text{ m}^3/\text{sec}$

f = fraction of inhaled radioiodine reaching the thyroid, 0.23

m = thyroid weight of standard man, 20 g

$$A = \frac{(2.32 \times 10^{-4} \text{ m}^3/\text{sec})(0.23)\chi}{20 \text{ g}}$$

$$\lambda_{eff} = 0.693/(\text{effective half-life for } {}^{131}\text{I})$$

$$\lambda_{eff} = (0.693)/7.6 \text{ days}$$

Substituting these parameters, the dose equation becomes:

$$D = \frac{(51.2)(0.23)(2.32 \times 10^{-4})(0.23)(7.6)\chi}{(20)(0.693)}$$

$$D(\text{rads}) = (3.45 \times 10^{-4} \frac{\text{rads} \cdot \text{m}^3}{\mu\text{Ci} \cdot \text{sec}})\chi\,(\frac{\mu\text{Ci} \cdot \text{sec}}{\text{m}^3})$$

$$\text{or,} \quad D(\text{mrad}) = (0.35 \frac{\text{mrad} \cdot \text{m}^3}{\mu\text{Ci} \cdot \text{sec}})\chi\,(\frac{\mu\text{Ci} \cdot \text{sec}}{\text{m}^3})$$

For the dose to a child's thyroid the above equation must be multiplied by a factor of 3 to account for differences in thyroid weight and breathing rates (m^3/day) between an adult and a child
(3 = 20 g/2 g x 6 m^3/20 m^3).

For other radioiodines the dose equation changes according to differences in effective half-life and effective decay energies. The dose equations for ^{133}I and ^{135}I are as follows:

$$^{133}I,\ D(mrad) = \left(\frac{0.093\ mrad \cdot m^3}{\mu Ci \cdot sec}\right)\chi$$

$$^{135}I,\ D(mrad) = \left(\frac{0.029\ mrad \cdot m^3}{\mu Ci \cdot sec}\right)\chi$$

In addition to differences in effective half-life and effective beta particle energies, the dose equation for ^{132}I is affected by the rapid decay of ^{132}I in the blood stream before it gets to the thyroid and by the decay rate of ^{132}Te, the precursor of ^{132}I. With these effects incorporated the dose equation for ^{132}I becomes

$$D(mrad) = (5.1 \times 10^{-2}\ mrad \cdot m^3/\mu Ci \cdot sec)\chi$$

where χ is the time-integrated concentration of ^{132}Te.

Dose from Ingestion of Radioiodines

For ingestion, parameter A, the total concentration of radioiodine to which the thyroid is exposed is defined by $A = \frac{CVf}{m}$ where,

C = the time-integrated concentration of radioiodine in milk, pCi·day/l

V = the rate at which milk is consumed by a child one year old or less, 1 liter/day

f = fraction of ingested radioiodine reaching the thyroid, 0.3

m = thyroid weight of a child one year old or less, 2 g

With the values for V, f, and m substituted,

$$A = \frac{(1 \text{ liter/day})\ (0.3)}{2 \text{ g}}\ C, \text{ or}$$

$$A = \frac{0.15 \text{ liter}}{\text{day} \cdot \text{g}}\ C$$

For ^{131}I the dose equation $D = KEA/\lambda_{eff}$ becomes applicable to milk ingestion with the above expression for A substituted.

$$D\ (\text{mrad}) = (5.12 \times 10^{-2}\ \frac{\text{mrad} \cdot \text{g} \cdot \text{dis}}{\text{MeV} \cdot \text{pCi} \cdot \text{day}})\ (0.23\ \frac{\text{MeV}}{\text{dis}})\ (\frac{0.15\ \text{l}}{\text{day} \cdot \text{g}})\ (\frac{7.6 \text{ day}}{0.693})\ C$$

$$\text{or, } D = \frac{(1.9 \times 10^{-2} \text{ mrad} \cdot \text{l})}{(\text{pCi} \cdot \text{day})}\ C$$

For other radioiodines, the above dose equation changes according to differences in effective half-life and effective decay energies to become:

$D = (5.2 \times 10^{-3})\ C$ for ^{133}I and

$D = (1.6 \times 10^{-3})\ C$ for ^{135}I.

Table 1B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/15/67.

Location Description	Azimuth and Distance From Test Cell C		Time Period Monitored	Cloud Arrival	GM Survey Meter Readings: Max. Net Gamma		Gamma Exposure
	Deg.	Mi	Hours	Time	(mR/h)	(Time)	(mR)
Lathrop Wells, Nevada	208	14.5	0830-1210	1138	0.5	1145	h
Lathrop Wells, Nevada	208	14.5	1100-1337	1130-1140	0.5	1145	0.2
Lathrop Wells, Nevada	208	14.5	1100-1215	1130-1140	0.5	1150	h
Lathrop Wells to Shoshone, California Highway 127	---	----	1238-1530	----	0.4[a]	1338	---
Goldspar Mine, Nevada	270	22.5	1100-1409	1145	0.04	1210	0
Lathrop Wells, Nevada	208	14.5	1100-1305	1138	0.5	1138	h
2.1 to 3 mi W Lathrop Wells, Highway 95	---	----	1225-1330	----	0.6[b]	1227	---
4.1 mi W Lathrop Wells, Highway 95	223	16.0	1130-1440	1140	0.6	1240	h
8.1 mi W Lathrop Wells, Highway 95	235	18.0	1200-1555	1210	0.8	1234	2.0
15 mi W Lathrop Wells, Highway 95	253	21.0	1115-1600	----	BKG	----	0

Table 1B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/15/67 (continued)

Location Description	Azimuth and Distance From Test Cell C		Time Period Monitored	Cloud Arrival	GM Survey Meter Readings: Max. Net Gamma		Gamma Exposure
	Deg.	Mi	Hours	Time	(mR/h)	(Time)	(mR)
16.5 mi W Lathrop Wells, Highway 95 to Lathrop Wells	---	----	1150-1252	----	0.8[c]	1234	---
Lathrop Wells to Death Valley Jct. California, Highway 29	---	----	1406-1441	----	0.1[i]	1438	---
25.1 mi W Lathrop Wells to Lathrop Wells	---	----	1140-1330	----	0.7[d]	1301	---
1.6 mi W Lathrop Wells to 25.1 mi W Lathrop Wells	---	----	1430-1510	----	0.1[e]	1438	---
Jct. 58 & 190 to Death Valley Jct., California Highway 150	---	----	1130-1607	----	0.6[f]	1555	---
12 mi S Red Mountain, California, Highway 395 to 20 mi N Jct. 395/14	---	----	1435-1735	----	0.1[g]	1540-1615	---
Glen Henderson Ranch Lathrop Wells, Nevada	215	21.0	1130-1450	1148	0.3	1251	0.11
James Price Ranch Lathrop Wells, Nevada	215	21.0	1100-1437	1145	0.3	1249	0.19
Dansby Ranch Lathrop Wells, Nevada	221	23.5	1110-1510	1240	1.1	1253	0.71

Table 1B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/15/67 (continued)

Location Description	Azimuth and Distance From Test Cell C Deg.	Mi	Time Period Monitored Hours	Cloud Arrival Time	GM Survey Meter Readings: Max. Net Gamma (mR/h)	(Time)	Gamma Exposure (mR)
Selbach/Strickland Ranch, Lathrop Wells, Nevada	222	24.0	1055-1240	1240	1.0	1257	1.3
McCarthy-Catlett Ranch Lathrop Wells, Nevada	233	21.0	1128-1505	1230	0.6	1256	1.8
Hord Ranch, Lathrop Wells, Nevada	223	23.5	1125-1600	1240	0.9	1252	0.82
Smith Ranch, Lathrop Wells, Nevada	210	26.5	1134-1452	1200	0.3	1315	0.42
Rich (Davis) Ranch Lathrop Wells, Nevada	214	23.5	1135-1350	1200	0.9	1255	0.32
Hopkins Ranch Lathrop Wells, Nevada	211	20.5	0900-1415	1150	0.1	1223	< 0.10
Salvatore Residence Lathrop Wells, Nevada	215	21.0	1145-1415	1145	0.3	1250	0.10
Nickell Ranch Lathrop Wells, Nevada	222	23.5	1100-1545	1230	1.0	1251	0.59
Corder Ranch Lathrop Wells, Nevada	223	23.5	1115-1420	1240	1.5	1251	1.1
Oswald Ranch Lathrop Wells, Nevada	223	24.0	1130-1510	1235	1.0	1252	0.95
Allison Ranch Lathrop Wells, Nevada	222	24.0	1130-1515	1230	1.0	1252	0.64

Table 1B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/15/67 (continued)

Location Description	Azimuth and Distance From Test Cell C Deg.	Mi	Time Period Monitored Hours	Cloud Arrival Time	GM Survey Meter Readings: Max. Net Gamma (mR/h)	(Time)	Gamma Exposure (mR)
Nicholl Residence Lathrop Wells, Nevada	220	23.0	1000-1500	1240	0.8	1251	0.76
Amargosa Substation Lathrop Wells, Nevada	213	24.0	1100-1445	1215	0.5	1257	0.82
Schultz Farm Lathrop Wells, Nevada	227	23.5	1115-1500	1230	0.8	1254-1258	1.1
Garey Ranch Lathrop Wells, Nevada	211	20.5	1100-1520	1143	0.2	1221	< 0.10
Fowler Ranch Lathrop Wells, Nevada	205	25.5	0930-1500	1205	0.2	1307	*
Rooker Ranch Lathrop Wells, Nevada	215	23.5	1030-1520	1240	0.5	1255-1300	0.80
Amargosa Mobile Trailer Court, Lathrop Wells, Nevada	214	22.0	0920-1506	1155	0.6	1250	0.55
Bryant Residence Lathrop Wells, Nevada	227	23.5	1134-1430	1230	0.6	1254	1.6
Beatty, Nevada	282	27.5	1120-1310	----	Bkg	----	0
Selback Residence Lathrop Wells, Nevada	212	20.0	1105-1510	1145	0.2	1225	0.18

[a] Reading at Death Valley Junction
[b] Reading at 3 mi W Lathrop Wells
[c] Reading at 3.9 mi W Lathrop Wells
[d] Reading at 7.9 mi W Lathrop Wells
[e] Reading at 4.1 mi W Lathrop Wells
[f] Reading at 24 mi SE Furnace Creek on Highway 190
[g] Reading at 5 mi S Junction 395/14
[h] Readings not taken frequently or long enough to determine exposure
[i] Reading at 1 mi N Death Valley Junction
* Readings not taken long enough to adequately determine integrated exposure

Table 2B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/16-17/67.

Location Description	Azimuth and Distance From Test Cell C Deg.	Mi	Time Period Monitored Hours	Cloud Arrival Time	GM Survey Meter Readings: Max. Net Gamma (mR/h)	(Time)
Dansby Ranch Lathrop Wells, Nevada	221	23.5	16/1000	----	Bkg	----
Dansby Ranch (Hay Stack) Lathrop Wells	221	23.5	16/1000	----	0.03*	----
Dansby Ranch Lathrop Wells, Nevada	221	23.5	17/1310	----	Bkg	----
Dansby Ranch (Hay Stack) Lathrop Wells	221	23.5	17/1316	----	Bkg	----
Nickell Ranch to 3 mi N of Ranch, Lathrop Wells, Nevada	222	23.5	16/1000	----	Bkg	----
Jct. Amargosa Rd/ Hwy 29 to 10 mi W then 10 mi N to Hwy 95, Lathrop Wells	---	----	16/1015-16/1250	----	Bkg	----
Death Valley Jct., California to Shoshone, California on Hwy 127	---	----	16/1050-16/1210	----	Bkg	----
Ash Meadows, California to Death Valley Jct., then 25 mi W of Furnace Creek Inn	---	----	16/1100	----	Bkg	----
Hord Ranch (Hay Stack) Lathrop Wells	223	23.5	16/1052-16/1055	----	0.04*	----
Hord Ranch (Hay Stack) Lathrop Wells	223	23.5	17/1355	----	Bkg	----
15 mi W Jct. Hwy 95/ 29 to 8 mi E, Lathrop Wells, Nevada	---	----	16/0910-16/1155	----	Bkg	----

Table 2B. Summary of radiation survey instrument readings, NRX-A6 EP IIIA - 12/16-17/67 (continued)

Location Description	Azimuth and Distance From Test Cell C		Time Period Monitored	Cloud Arrival	GM Survey Meter Readings: Max. Net Gamma	
	Deg.	Mi	Hours	Time	(mR/h)	(Time)
Rooker Ranch (Hay Stack) Lathrop Wells	215	23.5	17/1200	----	Bkg	----
Rooker Ranch Lathrop Wells, Nevada	215	23.5	17/1405	----	Bkg	----

*Reading on contact with haystack.

APPENDIX C

Air results, NRX-A6 EP-IIIA

Location	Collection Period Date & Time On / Off	Run Time Hrs (1)	Type*	Gross B pCi/m³	Gross B pCi·sec/m³	^{131}I pCi/m³	^{131}I pCi·sec/m³	^{132}Te pCi/m³	^{132}Te pCi·sec/m³	^{133}I pCi/m³	^{133}I pCi·sec/m³	^{134}I pCi/m³	^{134}I pCi·sec/m³	^{135}I pCi/m³	^{135}I pCi·sec/m³
Hord Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 222° 23 miles	12/15-1115 12/15-1610	4.9	PF CC	320 --	8.1 --	5.8 ND	0.16 ND	61 5.4	0.72 0.095	22 33	0.39 0.58	ND ND	ND ND	71 55	1.1 0.97
Nichell Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 222° 23 miles	12/15-1115 12/15-1600	4.8	PF CC	300 --	5.2 --	7.2 ND	0.12 ND	33 0.7	0.57 0.15	24 31	0.41 0.54	ND ND	ND ND	ND 41	ND 0.71
Price Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 219° 19 miles	12/15-1225 12/15-1445	2.5	PF CC	530 --	4.6 --	ND ND	ND ND	ND ND	ND ND	19 ND	0.17 ND	ND ND	ND ND	ND ND	ND ND
Lathrop Wells, Nevada 207° 14 miles	12/15-0900 12/15-1700	8.0	PF CC	110 --	3.2 --	ND ND	ND ND	9.3 6.2	0.27 0.18	5.1 12	0.15 0.35	ND ND	ND ND	ND 7.4	ND 0.21
Lathrop Wells, Nevada 207° 14 miles	12/15-1700 12/16-0630	13.5	PF CC	0.04 --	0.002 --	ND ND	ND ND	ND ND	ND ND	0.2 ND	0.01 ND	ND ND	ND ND	ND ND	ND ND
Lathrop Wells, Nevada 207° 14 miles	12/16-0655 12/17-0720	24.6	PF CC	0.1 --	0.01 --	ND ND	ND ND	ND ND	ND ND	0.4 0.8	0.04 0.07	ND ND	ND ND	ND ND	ND ND
Donoby's Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 219° 22 miles	12/15-1115 12/15-1550	3.6	PF CC	240 --	2.9 --	ND ND	ND ND	ND ND	ND ND	0.8 16	0.11 0.22	ND ND	ND ND	ND 2.8	ND 0.34
Donoby's Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 219° 22 miles	12/16-1420 12/17-1320	23.1 (2)	PF CC	0.2 --	0.02 --	ND ND	ND ND	ND ND	ND ND	ND 0.6	ND 0.06	ND ND	ND ND	ND ND	ND ND
Rocker Ranch, Amargosa Farm Area, Lathrop Wells, Nevada 215° 22 miles	12/15-1107 12/15-1525	1.9	PF CC	260 --	1.8 --	ND ND	ND ND	ND ND	ND ND	12 ND	0.082 ND	ND ND	ND ND	ND ND	ND ND
7.5 mi W Lathrop Wells, Nevada, Highway 95 233° 17 miles	12/15-1155 12/15-1620	4.5	PF CC	57 --	0.92 --	4.2 ND	0.068 ND	18 ND	0.29 ND	15 22	0.24 0.36	ND 15	ND 0.24	ND ND	ND ND
Death Valley Jct., California 191° 38 miles	12/15-0630 12/16-0730	25	PF CC	0.3 --	0.75 --	1.9 2.2	0.17 0.20	8.3 1.6	0.75 0.16	2.0 1.3	0.18 1.2	ND ND	ND ND	ND ND	ND ND
Death Valley Jct., California 191° 38 miles	12/16-0730 12/17-0730	24	PF CC	0.5 --	0.04 --	ND 0.6	ND 0.05	ND ND	ND ND	0.5 3.5	0.04 0.13	ND ND	ND ND	ND ND	ND ND
Death Valley Jct., California (3) 191° 38 miles	12/18-0630 12/19-0630	24	PF CC	< 0.1 --	ND --	ND 0.5	ND 0.04	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Junction Hwys 395 & 14 near Inyo/Kern, California 229° 129 miles	12/15-1615 12/16-1437	22.3	PF CC	2.6 --	0.21 --	0.8 1.3	0.06 0.10	2.6 ND	0.21 ND	1.9 4.8	0.15 0.39	ND ND	ND ND	ND ND	ND ND
Furnace Creek, California 233° 38 miles	12/15-1430 12/16-1230	22	PF CC	1.2 --	0.14 --	0.7 1.9	0.06 0.12	1.4 ND	0.11 ND	2.2 6.6	0.17 0.52	ND ND	ND ND	ND ND	ND ND
Furnace Creek, California 233° 38 miles	12/16-1230 12/17-1225	23.9	PF CC	0.2 --	0.02 --	ND 0.4	ND 0.03	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Furnace Creek, California 233° 38 miles	12/17-1225 12/18-1140	23.2	PF CC	< 0.1 --	-- --	0.1 ND	0.008 ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Shoshone, California 178° 58 miles	12/15-1548 12/16-1145	20.4	PF CC	1.6 --	0.12 --	ND	ND	1.4	0.10 NO CHARCOAL CARTRIDGE	2.1	0.15	ND	ND	ND	ND
Ridgecrest, California 223° 125 miles	12/15-1525 12/16-1232	21.1	PF CC	1.2 --	0.091 --	ND 0.8	ND 0.061	ND ND	ND ND	ND 3.8	ND 0.29	ND ND	ND ND	ND ND	ND ND
Ridgecrest, California 223° 125 miles	12/16-1235 12/17-1428	25.9	PF CC	< 0.1 --	ND --	ND 0.6	ND 0.04	ND ND	ND ND	ND 1.0	ND 0.093	ND ND	ND ND	ND ND	ND ND
Barstow, California 198° 139 miles	12/15-1435 12/16-0700	16.4	PF CC	0.4 --	0.02 --	0.2 1.3	0.01 0.077	ND ND	ND ND	ND 6.5	ND 0.38	ND ND	ND ND	ND ND	ND ND
Barstow, California 198° 139 miles	12/16-0700 12/17-0745	24.6	PF CC	0.6 --	0.05 --	0.5 1.0	0.04 0.068	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Barstow, California 198° 139 miles	12/17-0745 12/18-0700	23.3	PF CC	0.2 --	0.02 0.6	ND 0.05	ND ND	ND ND	ND 0.4	ND 0.03	ND ND	ND ND	ND ND	ND ND	ND ND
Barstow, California 198° 139 miles	12/18-0700 12/19-0700	23.9	PF CC	< 0.1 --	ND --	ND 0.2	ND 0.02	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Las Vegas, Nevada 129° 78 miles	12/15-0945 12/18-1435	76.8	PF CC	< 0.1 --	ND --	ND 0.1	ND 0.03	ND ND	ND ND	ND 0.1	ND 0.03	ND ND	ND ND	ND ND	ND ND
San Bernardino, California 197° 202 miles	12/15-1515 12/16-1525	24.4	PF CC	0.2 --	0.02 --	0.1 ND	0.009 ND	0.5 ND	0.04 ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
San Bernardino, California 197° 202 miles	12/16-1526 12/17-1505	23.6	PF CC	0.2 --	0.02 --	ND 0.2	ND 0.02	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND	ND ND
Fresno, California 269° 192 miles	12/16-1145 12/17-1120	23.6	PF CC	0.1 --	0.008 --	0.1 ND	0.008 ND	0.4 ND	0.03 ND	0.1 ND	0.008 NO	ND ND	ND ND	ND ND	ND ND
Silverlake, California (4) 176° 110 miles	12/15-1400 12/16-1400	24.0	PF CC	-- --	-- --	0.6	0.05	ND	NO PARTICULATE FILTER ND	ND	ND	ND	ND	ND	ND
Silverlake, California 176° 110 miles	12/17-1400 12/18-1400	24.0	PF CC	-- --	-- --	0.2	0.02	ND	NO PARTICULATE FILTER ND	ND	ND	ND	ND	ND	ND

PF - Particulate filter
CC - Charcoal cartridge
(1) - Running time is taken from a running time meter and may vary slightly from time difference between recorded on and off times.
(2) - Sampler was not in operation from 1550, 12/15 - 1420, 12/16.
(3) - No fresh fission products were found on the PF or CC that operated from 0730, 12/17 - 0683, 12/18.
(4) - Only charcoal cartridges were used on 12/15, 12/16, and 12/17 at this station. Iodine-131 was detected on 12/15 and 12/17. The maximum concentration was 0.052 pCi-sec/m³. These concentrations are obviously not comparable to an air sampler using a PF ahead of the CC.

APPENDIX D

Milk sampling results with associated milk cow feed results in parenthesis, NRX-A6 EP IIIA.

Name and Location of Dairy or Ranch	Date Milked	Radionuclide Concentrations ^{131}I	^{133}I	^{89}Sr	^{90}Sr
Barstow, California Bill Nelson Dairy 200° 141 miles	12/16	ND (ND[1])	80 (ND)	<5	<1
Barstow, California Bill Nelson Dairy 200° 141 miles	12/17	20 (ND)	50 (ND)	<5	2
Barstow, California Bill Nelson Dairy 200° 141 miles	12/18	ND (ND)	ND (ND)	7	<1
Barstow, California Bill Nelson Dairy 200° 141 miles	12/19	ND (ND)	ND (ND)	<5	1
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/15	ND (ND)	ND (900)	<5	1
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/16	90 (ND)	400 (5000)	<5	2
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/17	60 (2000)	200 (3000)	<5	<1
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/18	70 (ND)	30 (ND)	6	<1
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/19	30 (ND)	ND (ND)	<5	2
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/20	20 (ND)	ND (ND)	NO CHEMISTRY	

Milk sampling results with associated milk cow feed results in parenthesis, NRX-A6 EP IIIA. (continued)

Name and Location of Dairy or Ranch	Date Milked	Radionuclide Concentrations ^{131}I	^{133}I	^{89}Sr	^{90}Sr
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/21	ND (ND)	ND (ND)	<5	4
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/24	ND (NS)	ND (NS)	NO CHEMISTRY	
Lathrop Wells, Nevada Dansby's Ranch 219° 22 miles	12/26	ND (NS)	ND (NS)	NO CHEMISTRY	
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/16	ND (ND[2])	50 (2000)	<5	1
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/17	ND (ND)	60 (ND)	<5	<1
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/18	80 (ND)	50 (ND)	<5	<1
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/19	30 (ND)	ND (ND)	<5	1
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/20	ND (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/21	10 (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/23	ND (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Hord Ranch 222° 23 miles	12/25	ND (ND)	ND (ND)	NO CHEMISTRY	

APPENDIX D (continued)

Milk sampling results with associated milk cow feed results in parenthesis, NRX-A6 EP IIIA. (continued)

Name and Location of Dairy or Ranch	Date Milked	Radionuclide Concentrations ^{131}I	^{133}I	^{89}Sr	^{90}Sr
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/16	ND (100[3])	50 (2000)	<5	2
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/17	40 (400)	100 (700)	<5	<1
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/18	90 (800)	70 (600)	<5	3
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/19	70 (100)	20 (30)	<5	3
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/20	60 (ND)	ND (ND)	<5	6
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/21	70 (ND)	ND (ND)	<5	2
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/24	ND (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Rooker Ranch 215° 23 miles	12/26	ND (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/15	ND (ND)	ND (400)	<5	1
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/17	40 (ND)	80 (ND)	<5	1

APPENDIX D (continued)

Milk sampling results with associated milk cow feed results in parenthesis, NRX-A6 EP IIIA. (continued)

Name and Location of Dairy or Ranch	Date Milked	Radionuclide Concentrations ^{131}I	^{133}I	^{89}Sr	^{90}Sr
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/18	30 (ND)	20 (ND)	<5	<1
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/19	ND (ND)	ND (ND)	<5	<1
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/20	ND (ND)	ND (ND)	<5	<1
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/21	ND (ND)	ND (ND)	<5	4
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/24	ND (ND)	ND (ND)	NO CHEMISTRY	
Lathrop Wells, Nevada Tom Nickell Ranch 222° 23 miles	12/26	ND (ND)	ND (ND)	NO CHEMISTRY	
Olancha, California Hayhurst Ranch 247° 103 miles	12/16	ND (NS)	ND (NS)	<5	2
Olancha, California Hayhurst Ranch 247° 103 miles	12/17	ND (ND)	ND (ND)	<5	2
Olancha, California Hayhurst Ranch 247° 103 miles	12/18	20 (ND)	ND (ND)	<5	3

ND - Not detected
NS - No sample taken
1 - Only commercial feed was sampled at this dairy. All other samples of cow feed reported in this table were dry hay.
2 - 12/15 (^{131}I ND, ^{133}I 9600) No milk was available.
3 - 12/15 (^{131}I ND, ^{133}I 42,000) No milk was available
Note: Milk in pCi/l, Cow feed, in parenthesis, in pCi/kg

APPENDIX E

Milk sampling stations where no fresh fission products were detected, NRX-A6 EP-IIIA

Location of Dairy or Ranch	Date Milked						
Bakersfield, California Challenge Creamery 237° 181 miles	12/18	12/19	12/20	12/21	12/22	12/23	12/25
Barstow, California Hill's Dairy 200° 141 miles	12/16	12/17	12/18	12/19 (1)	12/20	12/22	12/23
Brawley, California Dateland Dairies 170° 272 miles	12/18	12/19	12/20	12/21	-----	-----	-----
Chino, California California Institute for Men 201° 211 miles	12/19	12/20	12/21	12/22 (1)	12/23	12/24	-----
Escondido, California Bernard Dairy 192° 258 miles	12/18 (1)	12/19	-----	-----	-----	-----	-----
Fresno, California Fresno College Creamery 269° 192 miles	12/23	12/24	-----	-----	-----	-----	-----
Hanford, California Superior Dairy 261° 189 miles	12/23	12/24	-----	-----	-----	-----	-----
Independence, California Smith Ranch 268° 108 miles	12/16	12/17	12/18	-----	-----	-----	-----
Independence, California Picard Ranch 270° 107 miles	12/16	12/17	12/18	-----	-----	-----	-----
Las Vegas, Nevada LDS Dairy Farm 125° 78 miles	12/20	-----	-----	-----	-----	-----	-----

APPENDIX E (continued)

Milk sampling stations where no fresh fission products were detected, NRX-A6 EP-IIIA (continued)

Location of Dairy or Ranch	Date Milked						
Lone Pine, California Lone Pine Dairy 262° 105 miles	12/17	12/18	-----	-----	-----	-----	-----
Newhall, California Burbank Creamery 218° 211 miles	12/18	12/19	12/20	12/21	12/22	12/23	12/24 (1)
Olancha, California Roy Hunter Ranch 247° 103 miles	12/16	12/17	12/18	-----	-----	-----	-----
Riverside, California Orange Crest Dairy 198° 203 miles	12/18	12/19	12/20	12/21	12/22	12/24	-----
San Luis Obispo, California Foremost Dairies 248° 262 miles	12/18	12/19	12/20	12/21	12/22	12/24 (1)	-----

(1) Two samples collected on this date